Remarks

In view of the following discussion, the applicants submit that the claims now pending in the application are not obvious under the provisions of 35 U. S. C. § 103. Thus, the applicants believe that all of these claims are in allowable form.

REJECTIONS

A. 35 U. S. C. § 103

1. Claims 1-6 and 9-14 are not unpatentable over Inuiya et al. in view of applicant's admitted prior art (AAPA)

Claims 1-6 and 9-14 stand rejected under 35 U. S. C. § 103(a) as being unpatentable over Inuiya et al. (U. S. Patent 6,084,632 issued July 4, 2000) in view of applicant's admitted prior art (AAPA). The applicants submit that these claims are not rendered obvious by the combination of these references.

Claim 1 relates to controlling the maximum charge that can be generated in a CCD or CMOS sensor in dependence of the gain applied to the output signal. The maximum charge accumulated in the photo sensitive regions of a CCD image sensor determines the maximum level of the signal provided by the CCD image sensor. Therefore, by controlling the maximum charge which can be accumulated in the photo sensitive regions of a CCD or CMOS image sensor the maximum level of the signal provided by the CCD or CMOS image sensor can be controlled.

Applicant's invention uses this finding for avoiding adverse effects of overexposed pixels on neighbouring pixels which are not overexposed, which effects may occur when the gain is set relatively high. The example provided on page 1 of the specification, for example assumes that the maximum charge

handling capacity of an exemplary image sensor amounts to 400% of a nominal charge for full exposure. If an image captured has very bright regions and regions of low light intensity those very bright regions may accumulate charges four times higher than the nominal charge considered full exposure. At the same time the regions of low light intensity may accumulate small charges corresponding to fractions of the nominal charge for full exposure. It may be desirable to amplify the signal generated from the small charges corresponding to the regions of low light intensity in order to obtain an image in which those regions are reproduced such that they can be viewed properly. However, since signal amplification is applied to signals coming from all pixels of the captured image, those signals corresponding to very bright regions are massively over-amplified. The exemplary figures provided in the example on page 1 of the specification shows a resulting signal corresponding to 1600% of a nominal charge for full exposure when 12 dB gain is applied to the signal. 1600%, however, correspond to a signal that is 16 times as high as a signal corresponding to a nominal charge for full exposure. A signal that is 16 times as high as a signal corresponding to nominal charge for full exposure generates unacceptable ringing and streaking, both inside the CCD image sensor during charge transfer and in the subsequent image transfer and processing.

According to the invention of claim 1, the maximum charge that can be accumulated in a pixel of the CCD image sensor is reduced when the gain by which the output signal is amplified is set high, thereby reducing adverse effects introduced during charge generation and transfer within the image sensor and in the subsequent image transfer and processing. As a result regions of rather low light intensity may be viewed properly, while overexposed regions are still reproduced as overexposed regions. However, the lack of information in overexposed regions remains limited to those regions which were actually overexposed during image capture, without adversely affecting neighbouring pixels which did not suffer from overexposure during image capture.

Inuiya et al. relates to a video camera that takes video images at a first frame or field rate having a first exposure time for each image taken and, at fixed time intervals, takes a single field or frame at a second exposure time that is shorter than the first exposure time. This is done in order to allow for sharp, crisp prints to be produced from the video signal. The prints are made only from those fields or frames taken at the shorter exposure time, because the fields or frames taken at the longer exposure time may appear blurred. Differences in brightness between the two types of images occur because an image taken at a shorter exposure time cannot integrate the same amount of light than an image taken at a longer exposure time. The prior art suggests equalizing the perceived brightness of two pictures taken at two different exposure times (*see*, Inuiya et al. at column 2, lines 28-32). Equalisation is done by controlling the gain of an amplifier (*see*, Inuiya et al. at column 4, lines 50-67).

Inuiya et al. absolutely fails to disclose changing the magnitude of the driving signal that is applied to the CCD sensor for controlling the amount of charge that is read out from the CCD sensor for further processing. Applicant is unable to identify this particular feature in column 23, lines 16-55 and Fig. 10, "12" and "120" of Inuiya et al.

The Examiner further indicates that, at the time of the invention, the skilled person would consider equivalent two possibilities for controlling the maximum charge that can be accumulated in an image sensor, notably controlling the exposure time or controlling the amplitude of the driving pulses.

Applicant's statement in the reply to the prior office action and referred to by the Examiner was made in order to allow for understanding the invention and did not include any statement as to what was known at the time the invention was made. Further, applicant's statement only referred to CCD or CMOS without elucidating the substantial differences that exist between these two technologies. In fact, the magnitude of the reset pulse cannot be used for determining the maximum charge that can be accumulated in a CMOS sensor. Rather, the magnitude of the reset pulse determines the maximum charge that can be

discharged in a CMOS image sensor. This is due to the design of CMOS image sensors, in which a capacitor is charged by the reset pulse and discharged through a diode, the momentary current through which is determined by the momentary illumination of the diode. The charge becomes smaller the more light impinges on the sensor over time, and a constant level of illumination is assumed over the exposure period. Hence, since in a CMOS sensor the maximum level that can be achieved is predetermined, the overexposure problem can never occur.

The reset signal in a CCD sensor, however, has a different function. In a CCD sensor the charges are actually generated through light impinging on a sensor. The charges are collected in a region of the CCD sensor referred to as "potential well". Traditionally, the reset signal in a CCD sensor is used to empty the potential well prior to a new exposure period, e.g. in case not all of the charges were transferred into the transfer region of the sensor. The following figure shows the operating principle of a CCD image sensor:

Anatomy of a Charge Coupled Device (CCD)

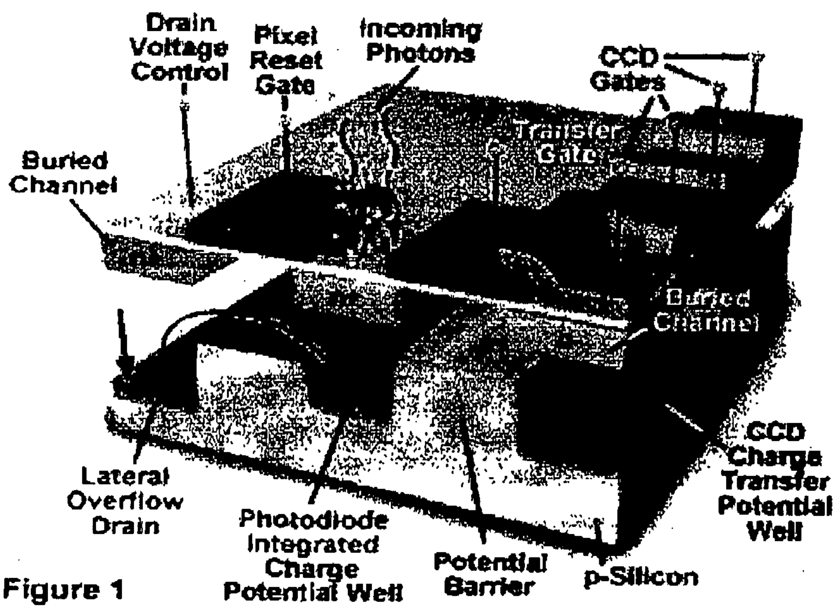

Figure 1

The region designated "photo diode integrated charge potential well" is the active area of the sensor. Potential barriers to the left and the right of the potential well keep the accumulated charge contained during exposure. After exposure the potential barrier to the right is lowered, allowing the accumulated charge to flow into charge transfer region of the sensor, through which it is ultimately transferred to the output of the sensor. The reset signal may be used in a known manner to ensure that the potential well is completely depleted of any existing charge before a new exposure period begins.

According to the invention the gate electrode associated to the reset signal is controlled in a different manner: The potential at the reset electrode is set to or maintained at a level selected, in accordance with the gain that is applied after reading out the sensor, to allow charges that may be generated, exceeding the height of the barrier, to flow into an overflow channel, thus limiting the maximum charge that can be accumulated in the potential well. It is submitted that this use of the control signals in a CCD image sensor is new over the prior art and not obvious.

Further, without prejudice to what was known at the time of the invention, reducing the maximum charge by either controlling the driving pulse amplitude or controlling the exposure time produce significantly different results. For example, when a very bright light source illuminates the imager a pixel will always saturate, irrespective of the exposure time. The maximum charge is the same as would have been generated by a less bright light source at a longer exposure time. In this case, the saturated pixel affects the neighbouring pixels in the undesired way that is avoided by the invention as claimed in the currently pending application. It is apparent that the maximum amount of charge of that can be generated in a saturated pixel is part of the problem. Changing the driving signal amplitude, however, as suggested in the presently pending application, reduces the maximum amount of charge that can be generated in the pixel, and thereby greatly reduces if not eliminates the problem.

As a further non-obvious advantage of the invention, keeping the exposure time constant and reducing the maximum charge that can be accumulated in case of high gain allows for darker image areas to contribute to the image in the known manner, without being affected or limited in any way, while bright areas are overexposed anyway. The overexposed areas, however, cause less or no ringing and streaking, because the maximum accumulated charge is reduced.

In contrast, by reducing the exposure time the prior art does not control the maximum or saturated output signal but rather the sensitivity of the sensor. This can be considered as a kind of attenuation, which is insufficient so as to solve the problem and causes other unintended changes, as has been shown in the example above.

Further, changing the integration time may not be allowed in broadcast applications and professional video capturing because it changes the creative intent of the director or cameraman. A fixed integration time produces a constant motion blur, which may be artistically intended. A shortened integration time that is not under control of the director or cameraman, because it depends, inter alia, from the illumination of the set may not be desired. The crisp images resulting from the shortened exposure time may not be wanted form an artistic point of view, and could disturb the overall impression of the video.

In view of the discussion above, the person of ordinary skill in the art would not consider Inuiya et al. as a departing point for making the invention, and also would not use the alleged AAPA <u>because the function, the way and the effect taught in Inuiya et al. and the function, the way and the effect of the invention are not equivalent</u>. Not only are the objects of the two ways of reducing the charge very different from: reducing the exposure time avoids motion blur, reducing the amplitude of the reset pulse avoids streaking/ringing. Also, the invention as claimed in the present application, as opposed to the prior art of Inuiya et al., allows for maintaining a selected exposure time while still reducing or eliminating streaking and ringing in the image. This is an advantage over the

prior art in case changing the exposure time is not desired or allowed. This is a significant, non-obvious difference between the invention and the prior art.

Further, the combination of Inuiya et al. with allegedly known interrelated effects between amplitude of driving signals and maximum charge generated appears to result from improper hindsight. Once the problem is identified and tied to the "nominal" maximum charge, reducing the charge appears to be straightforward. However, using the prior art of Inuiya et al. for reducing the maximum charge produces significantly different results, as has been shown further above. It is, therefore, submitted that the invention as claimed in the claims is not obvious over Inuiya in view of the alleged AAPA.

Claims 2-6 are directly, or indirectly, depending from and add further limitation to allowable claim 1. Consequently, claims 2-6 are also patentable.

The same argumentation as for claim 1 applies, mutatis mutandis, for claim 9.

The same argumentation as for claim 5 applies, mutatis mutandis, for claim 10.

As to the rejection of claims 11 and 12 as being unpatentable over Inuiya in view of AAPA: Inuiya and AAPA fail to render obvious reducing the magnitude of the driving pulses with increasing gain. See the discussion of claim 1 further above. Rather, Inuiya teaches increasing the gain when the overall <u>signal level</u> is low due to a reduced exposure time, which is a result of the reduced exposure time rather than an effort to reduce streaking and ringing. The reduced exposure time is chosen in Inuiya for completely different reasons than the reduced maximum charge (avoiding image blur vs. avoiding streaking and ringing from overexposure). As was stated further above, the invention allows for less bright objects to create charges just as normal, without being affected by reduced integration time, while brighter objects may quickly create the maximum possible charge and cannot create excess charge resulting from overexposure. Therefore, the matter of claims 11 and 12 is not rendered obvious by Inuiya in view of alleged AAPA.

The same argumentation as for claim 1 applies, mutatis mutandis, for claim 13.

The same argumentation as for claim 11 applies, mutatis mutandis, for claim 14.

2. Claim 7 is not unpatentable over Inuiya et al. in view of applicant's admitted prior art (AAPA) in further view of Topper

Claim 7 stands rejected under 35 U. S. C. § 103(a) as being unpatentable over Inuiya et al. (U. S. Patent 6,084,632 issued July 4, 2000) in view of applicant's admitted prior art (AAPA) in further view of Topper (US Patent 4,683,498 issued July 28, 1987). The applicants submit that this claim is not rendered obvious by the combination of these references.

Claim 7 relates to controlling the maximum charge that can be generated in a CCD or CMOS sensor in dependence of the gain applied to the output signal. As is known to the person ordinarily skilled in the art, the amplitude of the control signals, notably the reset pulse, determines the maximum charge that can be accumulated in the photosensitive regions of a CCD or CMOS image sensor during exposure by light impinging on the sensor. The maximum charge accumulated in the photo sensitive regions of a CCD or CMOS image sensor, however, determines the maximum level of the signal provided by the CCD image sensor. Therefore, by controlling the maximum charge which can be accumulated in the photo sensitive regions of a CCD or CMOS image sensor the maximum level of the signal provided by the CCD or CMOS image sensor can be controlled.

The invention recited in claim 7 uses this finding for avoiding adverse effects of overexposed pixels on neighbouring pixels which are not overexposed, which effects may occur when the gain is set relatively high. The example provided on page 1 of the specification, for example, assumes that the maximum charge handing capacity of an exemplary image sensor amounts to 400% of a nominal charge for full exposure. If an image captured has very bright regions

and regions of low light intensity those very bright regions may accumulate charges four times higher than the nominal charge for full exposure. At the same time the regions of low light intensity may accumulate small charges corresponding to fractions of the nominal charge for full exposure. It may be desirable to amplify the signal generated from the small charges corresponding to the regions of low light intensity in order to obtain an image in which those regions are reproduced such that they can be viewed properly. However, since signal amplification is applied to signals coming from all pixels of the captured image, those signals corresponding to very bright regions are massively over-amplified. The exemplary figures provided in the example on page 1 of the specification shows a resulting signal corresponding to 1600% of a nominal charge for full exposure when 12 dB gain is applied to the signal. 1600%, however, correspond to a signal that is 16 times as high as a signal corresponding to a nominal charge for full exposure. A signal that is 16 times as high as a signal corresponding to nominal charge for full exposure generates unacceptable ringing and streaking, both inside the CCD image sensor during charge transfer and in the subsequent image transfer and processing. According to the invention the maximum charge that can be accumulated in a pixel of the CCD image sensor is reduced when the gain by which the output signal is amplified is set high, thereby reducing adverse effects introduced during charge transfer within the image sensor and in the subsequent image transfer and processing. As a result regions of rather low light intensity may be viewed properly, while overexposed regions are still reproduced as overexposed regions. However, the lack of information in overexposed regions remains limited to those regions which were actually overexposed during image capture, without adversely affecting neighbouring pixels which did not suffer from overexposure during image capture.

Inuiya et al. relates to a video camera that takes video images at a first frame or field rate having a first exposure time for each image taken and, at fixed time intervals, takes a single field or frame at a second exposure time that is

shorter than the first exposure time. This is done in order to allow for sharp, crisp prints to be produced from the video signal. The prints are made only from those fields or frames taken at the shorter exposure time, because the fields or frames taken at the longer exposure time may appear blurred. Differences in brightness between the two types of images occur because an image taken at a shorter exposure time cannot integrate the same amount of light than an image taken at a longer exposure time. The prior art suggests equalizing the perceived brightness of two pictures taken at two different exposure times (*see*, Inuiya et al. at column 2, lines 28-32). Equalisation is done by controlling the gain of an amplifier (*see*, Inuiya et al. at column 4, lines 50-67).

Inuiya et al. absolutely fails to disclose changing the magnitude of the driving signal that is applied to the CCD sensor for controlling the amount of charge that is read out from the CCD sensor for further processing. Applicant is unable to identify this particular feature in column 23, lines 16-55 and Fig. 10, "12" and "120" of Inuiya et al.

In view of the discussion above, the person of ordinary skill in the art would not consider Inuiya et al. as a departing point for making the invention, and also would not use the alleged AAPA <u>because the function, the way and the effect taught in Inuiya et al. and the function, the way and the effect of the invention are not equivalent</u>. Not only are the objects of the two ways of reducing the charge very different from: reducing the exposure time avoids motion blur, reducing the amplitude of the reset pulse avoids streaking/ringing. Also, the invention as claimed in the present application, as opposed to the prior art of Inuiya et al., allows for maintaining a selected exposure time while still reducing or eliminating streaking and ringing in the image. This is an advantage over the prior art in case changing the exposure time is not desired or allowed. This is a significant, non-obvious difference between the invention and the prior art.

Further, the combination of Inuiya et al. with allegedly known interrelated effects between amplitude of driving signals and maximum charge generated appears to result from improper hindsight. Once the problem is identified and tied

to the "nominal" maximum charge, reducing the charge appears to be straightforward. However, using the prior art of Inuiya et al. for reducing the maximum charge produces significantly different results, as has been shown further above. It is, therefore, submitted that the invention as claimed in the claims is not obvious over Inuiya in view of the alleged AAPA.

Topper describes an image pick-up device including three image sensors 14, 16, 18 (*see*, Topper at FIG. 1 and column 3, lines 13-28).

Topper does not describe or suggest an arrangement to control the maximum charge which can be accumulated in the photo sensitive regions of a CCD or CMOS image sensor in order to control the maximum level of the signal provided by the CCD or CMOS image sensor.

In view of the discussion above, and since Inuiya et al. in view of applicant's admitted prior art (AAPA) in further view of Topper, fails to teach controlling the maximum output signal amplitude that can be output by the image sensor, the invention as claimed in claim 7 is patentable over the combination of these references

CONCLUSION

Thus, the applicants submit that none of the claims presently in the application are obvious under the provisions of 35 U. S. C. § 103. Consequently, the applicants believe that all of the claims are presently in condition for allowance. Accordingly, both reconsideration of this application and its swift passage to issue are earnestly solicited.

If, however, the Examiner believes that there are any unresolved issues requiring adverse final action in any of the claims now pending in the application,

it is requested that the Examiner telephone Ms. Patricia A. Verlangieri, at (609) 734-6867, so that appropriate arrangements can be made for resolving such issues as expeditiously as possible.

Respectfully submitted,

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